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LARGE SLEWING BEARINGS

TECHNICAL SPECIFICATION

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SYMBOLS AND UNITS:

Table 1.1. – Symbols and units

Symbol	Units	Definition
Dz	mm	Outer diameter
Dn	mm	Inner diameter
H	mm	Overall height
Lz	mm	External bolt pitch circle diameter
Ln	mm	Internal bolt pitch circle diameter
n	-	Number of bolt holes per hole circle
B	mm	Bolt hole diameter
M	mm	Bolt size
O	mm	Diameter
U	mm	Diameter
H1	mm	Ring height
H2	mm	Ring height
Hu	mm	Distance at the bottom Outer ring / Inner ring
Ho	mm	Distance at the top Outer ring / Inner ring
d	mm	Gear P.C.D.
m	mm	Module
z	-	Number of teeth
x.m	mm	Addendum modification (profile shift)
b	mm	Tooth width
T		Weight
t	mm	Thread depth
Zu	mm	Diameter
v	m/s	Speed
hu	mm	Tooth height
F_a	kN	Resultant axial force
F_r	kN	Resultant radial force
F_t	kN	Resultant tangential force
M_k	kNm	Resultant tilting (overturning) moment
M_t	kNm	Resultant rotational moment (derived from tangential force F_t)

1. SLEWING BEARING BASIC COMPONENTS

Triple row roller slewing bearing:

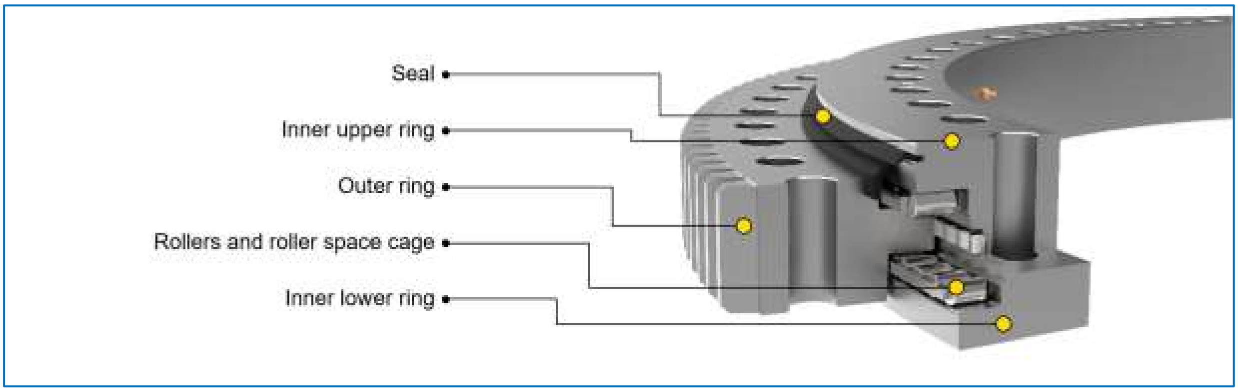


Figure 1.1. – Components of a tripple row roller slewing bearing

Ball slewing bearing:

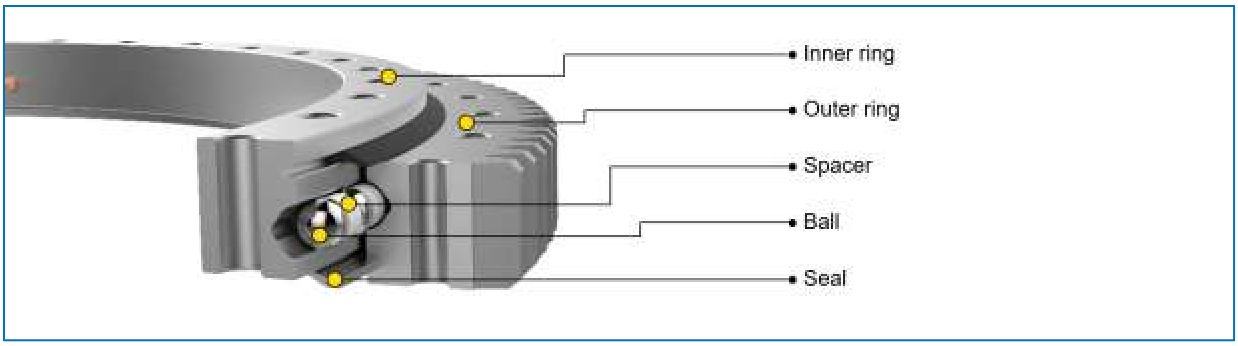


Figure 1.2. – Components of a ball slewing bearing

Cross-roller slewing bearing:

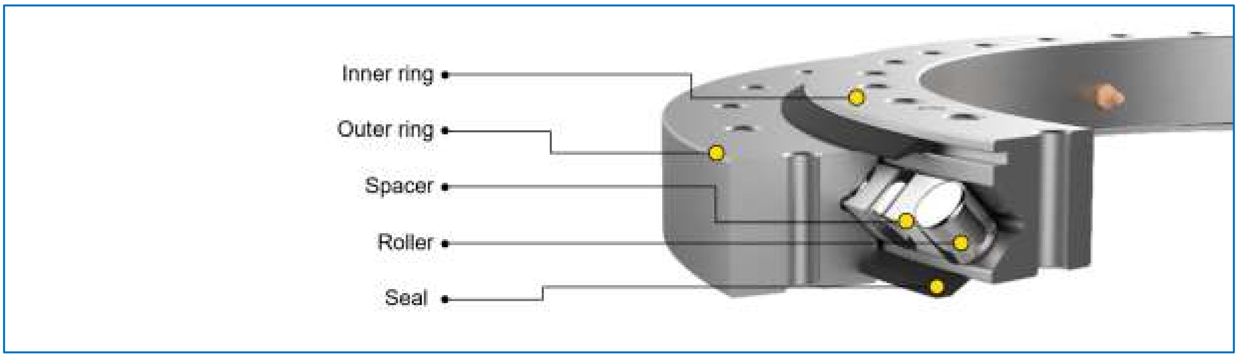


Figure 1.3. – Components of a cross-roller slewing bearing

1.1. BEARING DESIGNATION STRUCTURE

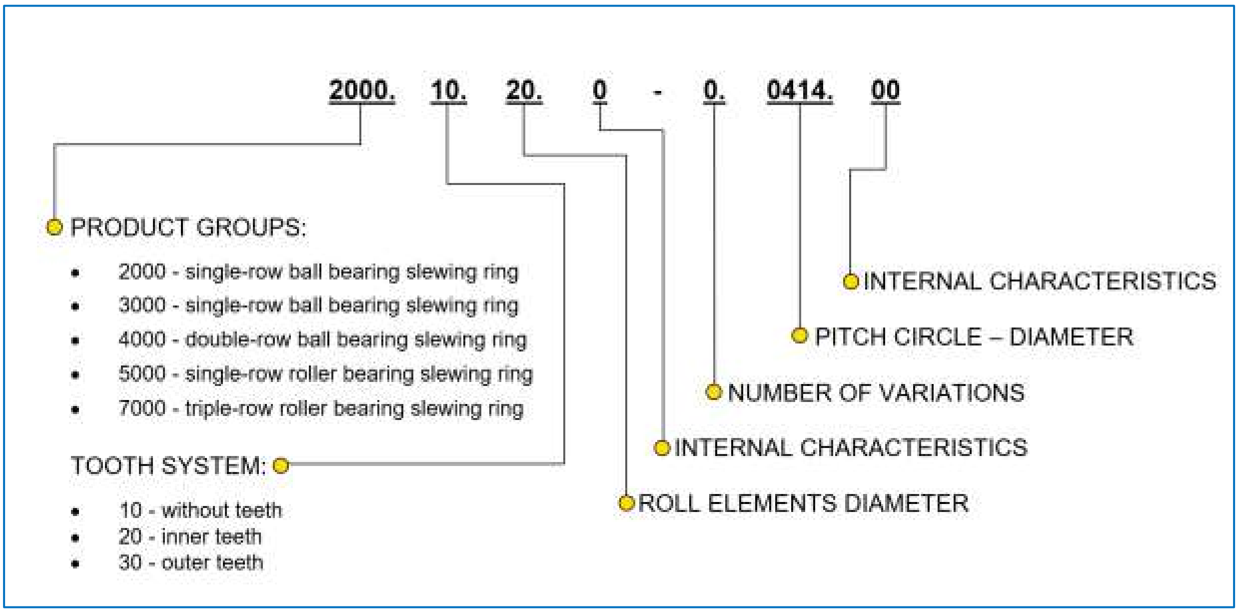


Figure 1.4. – Bearing designation structure

2. MATERIALS

The slewing bearing components are made of selected standard high quality materials best suited for their intended use.

2.1. SLEWING RINGS

Rotis uses a variety of steel whose differing structural conditions (normalized or tempered) allow them to be used for the most varied of applications whereby tempered steel is far better suited for the manufacture of both bearings and gears subjected to higher load conditions than is normalized steel.

For the manufacture of slewing rings Rotis defines the materials best suited for their intended application in its product concepts catalogue. These materials are then manufactured from type-tested steel.

Each step of production undergoes controls ensuring the quality of the products. In the majority of cases, fine steel with carbon additives and alloys are selected best suited to their functional requirements.

The tempering method through quench hardening or artificial ageing is then selected when the forces which the work pieces are subjected to make this necessary.

Slewing rings are made of seamlessly rolled rings from low alloy heat treatable steel, of which are in the majority C45+QT and 42CrMo4+QT, according to EN ISO 683-2:2018 and EN ISO 683-3:2018 which replace the standards EN 10083-2:2006 and EN 10083-3:2006 respectively, with stricter requirements to guarantee a temperature range of application from - 20°C. Rotis can guarantee upon request a quotation for lower temperatures too. Material is tested for essential mechanical and chemical properties, to assure the required toughness and strength of the final product. For special requirements, Acceptance Test Certificates 3.1 acc. to EN 10204 can be provided.

For specific applications or special functional requirements the use of other materials is possible, for instance:

- Stainless steel
- Hardened steel or alloys
- Steel tempered in controlled atmospheres
- Carburized or nitrated steel
- Special steel for extremely low temperatures
- Light alloys on an aluminium base

2.1.1. COMPARISON OF STEEL DESIGNATION

Table 2.1. below shows the designations for two widely used steels by country and by number acc. To EN ISO 683-2:2018 and EN ISO 683-3:2018 which replace the standards EN 10083-2:2006 and EN 10083-3:2006.

Table 2.1. – Steel designations for different countries

Country	Standard designations		
Steel number (EN 10027-2)		**1.1191**	**1.7225**
GERMANY	DIN	Ck 45	42CrMo4
ITALY	UNI	C45	42CrMo4
SPAIN	UNE	C45K (F1140)	42CrMo4 (F8232)
JAPAN	JIS	S45C	SNB7
SWEDEN	SS	1672	2244
U.S.A	AISI	16B45	4142

2.2. ROLLING ELEMENTS

For ball slewing bearings the rolling elements standardly used correspond to DIN 5401 and for roller slewing bearings cylindrical rollers acc. to DIN 5402 are used. The material for the rolling elements corresponds to 100Cr6 acc. to ISO 683-17. Upon request other materials can be used.

2.3. SPACER ELEMENTS

Elements used for rolling elements separation (Figure 2.1. to Figure 2.5. – Cross-roller spacer elements) are made of PA6, PA1010 or PVC, depending on the application and environment. Rotis can also provide fiberglass-reinforced spacers.

For higher temperatures above 70°C or other special applications, brass spacers or spacer cages from structural steel S355J2G3 are used. Other materials can be applied according to requirements.

Figure 2.1. – Basic ball spacer elements

Figure 2.2. – Ball bearing cage

Figure 2.3. – Axial roller spacer cage

Figure 2.4. – Radial and axial roller spacer elements

Figure 2.5. – Cross-roller spacer elements

2.4. INTEGRAL SEALING PROFILES

Rotis slewing bearings are usually designed with integral seals on both sides of the raceway system. The role of a sealing system is to prevent the contamination of the raceway system from moisture, other foreign particles, and to retain the lubricant contained in the raceway.

The basic material used is nitrile butadiene rubber (NBR), more specifically NBR 70. For elevated temperatures viton or silicon based sealing profiles can be applied.

Various sealing systems can be supplied. The basic type of sealing system (Figure 2.6.) is adequate for use in construction machinery, onshore & offshore applications or in general machine design applications.

When special requirements are present, other types of sealing profiles and arrangements, internal, radial, tandem or labyrinth systems can be applied.

In spite of the usage of selected materials optimized for their intended use, sealing profiles are subjected to wear caused by the effects of environmental factors that cannot be eliminated and for that sealing profiles should be routinely checked and replaced if necessary. Structures in the vicinity of the sealing profiles should be designed as such not to pose any danger of damage occurring.

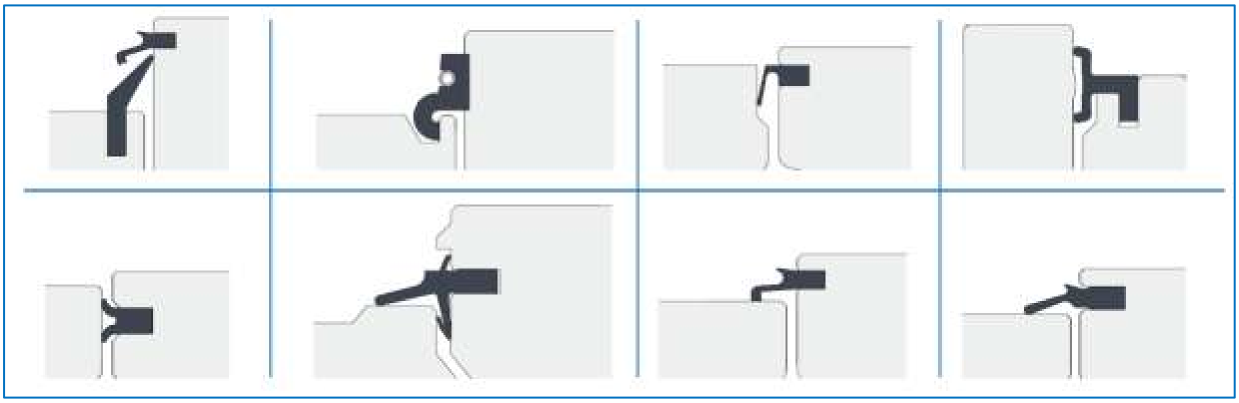


Figure 2.6. – Basic sealing profile types

2.5. LUBRICATION SYSTEM

Figure 2.7. – Lubrication port with a basic standard grease nipple

Rotis standard slewing bearings are equipped with a lubrication system for lubricating the bearing raceway. Lubrication ports are normally arranged radially and have an M10x1 metric thread and fitted with a standard straight steel lubrication nipple acc. to DIN 71412 (Figure 2.7.). Other arrangements, i.e. axially arranged, with alternative sizes and shapes of grease nipples or threads that are available on request. In case grease nipples are not provided by Rotis, standard plastic plugs are used if not requested otherwise.

2.6. SLEWING BEARING RACEWAY

Rotis slewing bearings raceways are always induction hardened to ensure the highest bearing capacity and a prolonged lifetime. The hardness achieved is in a rangefrom 56 to 59 HRc. The depth of the hardened layer is governed by the maximum shear stress according to the theory of contact mechanics (Figure 2.8. and Figure 2.9.) and by the size of the rolling element.

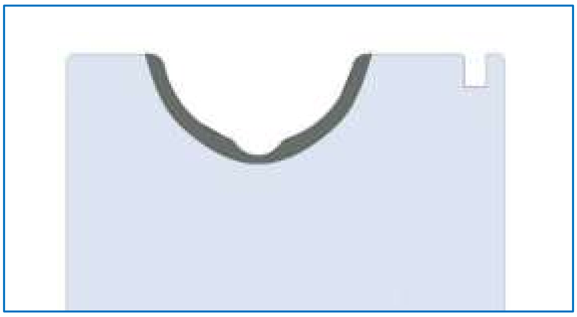


Figure 2.8. – Ball bearing raceway hardened layer

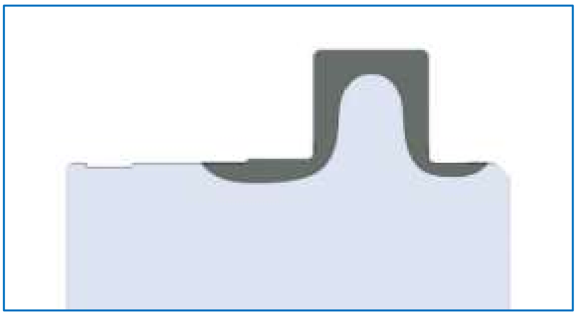


Figure 2.9. – Tripple row roller raceway hardened layer

2.7. SLEWING BEARING GEAR

Rotis slewing bearings can incorporate gears to transmit torque applied by the pinion/s to further optimize the mass and cost, and eliminate the need for additional gear rings.

2.7.1. GEAR HARDNESS

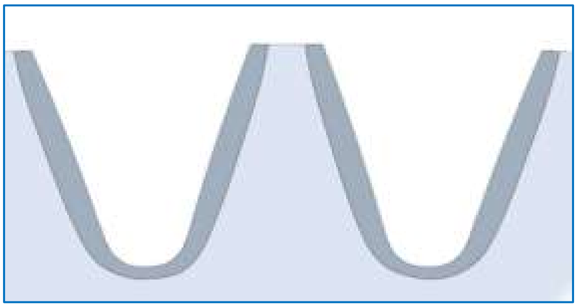


Figure 2.10. – Gear gap hardening

Gear teeth are normally left untreated, in the condition of the basic material, and possessing its properties. Therefore the hardness of the gear teeth is the same as that of the basic material.

If subjected to higher demands in their lifetime and/or higher demands on the permissible tooth force for a given design, the gears can be inductively hardened. Depending on the tooth's normal module size, the gears are hardened throughout or gap hardened (only the tooth flanks and roots are hardened, leaving the top gap to prevent brittleness), see (Figure 2.9.). The depth of hardening is calculated based on the size of a normal module with a surface hardness of 55±4HRc. This has proved to be the optimal depth for the prevention of pitting and root fracture.

2.7.2. GEAR QUALITY

Standard gear teeth are manufactured according to quality grade 12 and according to standard ISO 1328. Higher quality grades are possible on request. The normal modulus range is for outer gears from 5mm to 24mm and for inner gears from 5mm to 20mm in depth. On request, helix spur gears and other gear types are possible, such as timing belt gears or chain gears.

2.7.3. REFERENCE PROFILE

The standard reference profile used is according to DIN 3972 II. Other reference profiles are possible on request.

2.7.4. TOOTH THICKNESS DEVIATION

If not specified otherwise, the deviation of tooth thickness is manufactured according to DIN 3967 tolerance class "cd 27".

2.7.5. GEAR RUNOUT

The maximum gear runout is affected by numerous factors, mostly by gear hardening. Maximum runout tolerances for both hardened and non-hardened gears are presented in (Figure 2.11.).

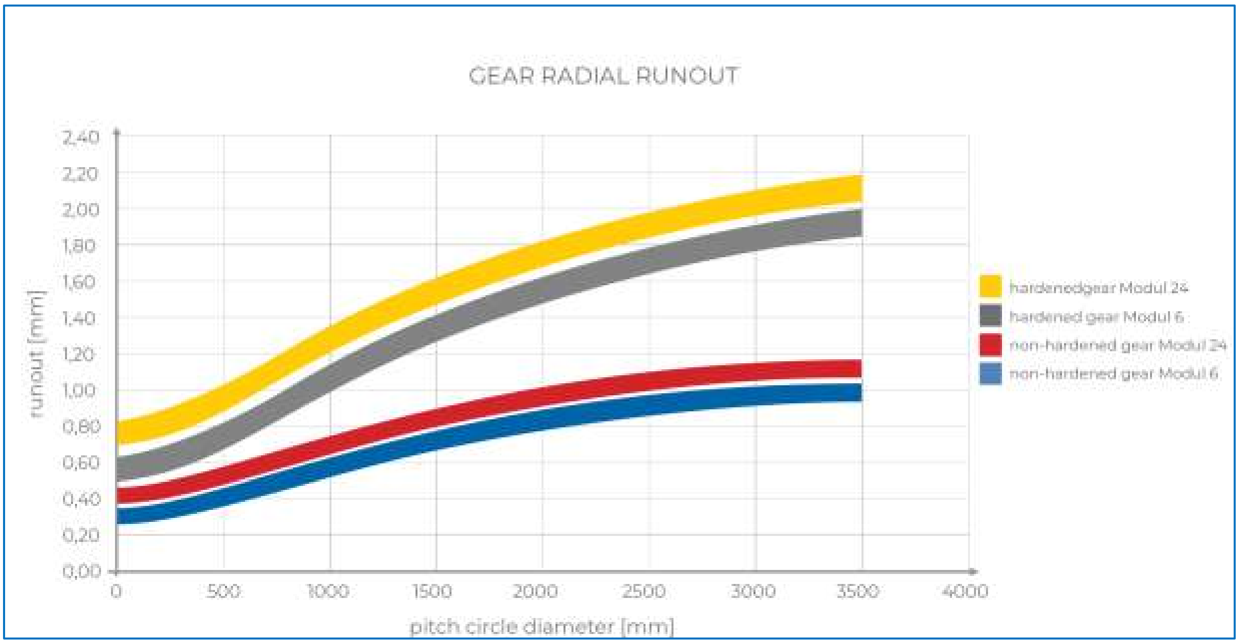


Figure 2.11. – Gear runout diagram for hardened and non hardened gear (for module 6...24 mm, PCD up to 5,000 mm)

The position of the maximum runout is indicated by three teeth painted with a green colour, the middle one being the tooth with the maximum runout, stamped with a “+” sign in the case of the outer gear and a “-” sign in the case of the inner gear (Figure 2.12.).

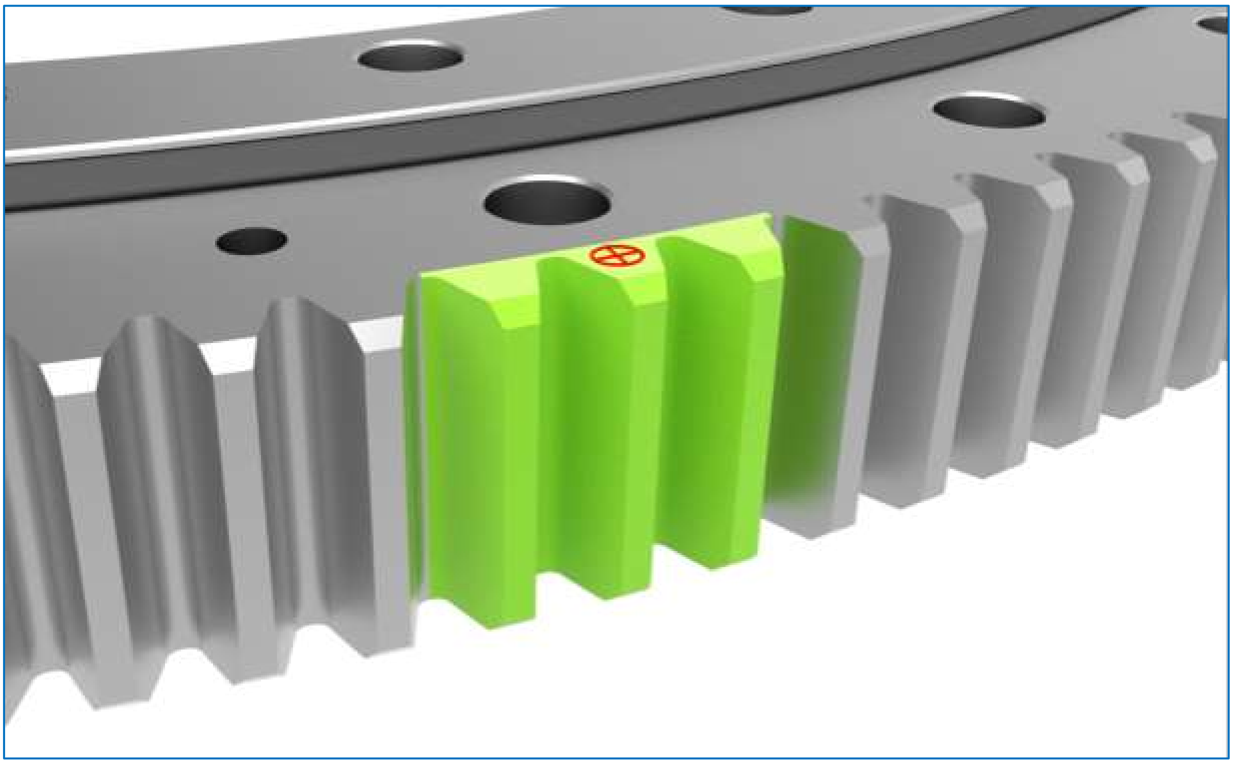


Figure 2.12. – Painted identification of the maximum or minimum gear runout with a stamped sign

2.7.6. PINION

The gear rings are designed for meshing pinions with the same module and with a recommended positive profile shift, which should be the minimum of half the normal module. The pinion face width should be at least the same size as the face width of the bearing gear, preferably wider for a normal module. Pinions should generally be made of a better material than the material of the bearing gear with a surface quality Q9 according to DIN 3967 and a tolerance class of “c26” or lower. The standard recommended materials for pinions are 42CrMo4V, 16MnCr5 or 18CrNiMo7-6 according to ISO 6336-5. In case of a higher torque requirement, multiple pinions should be used in order to reduce the force on the teeth.

If a pinion is not defined, upon request, Rotis can suggest a tooth geometry and the number of teeth that the pinion should have.

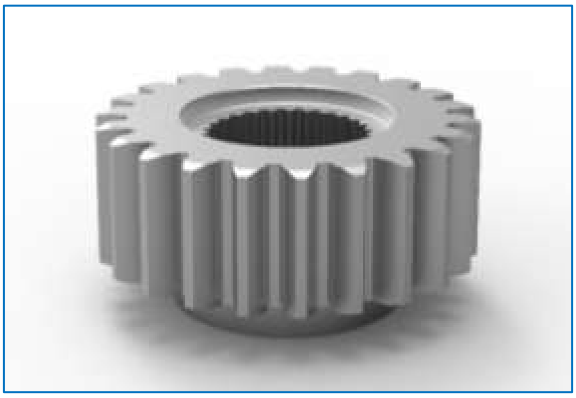


Figure 2.13. – Pinion

2.8. CORROSION PROTECTION SYSTEM

The prevention of corrosion of the outer metallic surfaces is achieved by various techniques and for the severity of various environment factors.

2.8.1. BASIC CORROSION PROTECTION

Standard Rotis slewing bearings are protected with oil-based Castrol Rustilo 181 or with the corrosion preventive compound TECTYL, for a temporary protection of up to 12 months only.

2.8.2. PAINT COATINGS

On request, slewing bearings can be protected with a wide range of coatings and colour systems, from the “Zinc rich coatings” repertoire, and from one up to four layers.

2.8.3. ZYNC COATINGS

Zync electroplating can be applied for an ultra thin additional protection (also on mating surfaces), with or without subsequent paint coatings. For demanding applications, zync flame spraying acc. to EN 22063 can be applied on non-mating surfaces, again with or without subsequent coatings of paint.

2.9. GREASE

Rotis large slewing bearings should be relubricated before the first run test, and prior to putting the slewing bearing into operation, so the slewing bearing raceway is adequately filled with grease. Provided grease in slewing bearing raceway is based on a mineral oil and a lithium soap thickener for extreme pressures and with anti-wear properties. The slewing bearing gear is protected with oil during shipping. In case longer storage times are requested, additional protection is applied. Castrol SPHEEROL EPL2 greases or its equivalents are generally used for raceway systems. In case of elevated temperatures, Mobil Mobilith SHC 460 or equivalents are used. For additional standard raceway and gear lubricants please refer to Table 6.2 Standard greases for raceway systems and gears.

During installation and commissioning, it is necessary to re-lubricate the bearing until grease exits from beneath the seal. While re-greasing, the bearing must be rotated.

3. SELECTION OF THE SLEWING BEARING TYPES

3.1. LOAD DETERMINATION

Large slewing bearings are used to transmit the load from a rotating on to a stationary part. For that it must have the required capacity. In order to select a slewing bearing suitable for a specific application, the forces acting on the connecting structure must be defined. This requires an in-depth knowledge of the forces present and their subsequent effect on the slewing ring, including the forces due to the mass inertia of the load and of the upper structure.

A knowledge of the direction of the forces with regard to the axis of the slewing bearing is necessary. One thus distinguishes between the axial and the radial force, the tilting (overturning) moment and the rotational moment or torque.

3.1.1. AXIAL FORCE

Forces acting in the direction parallel to the axis of rotation are called axial forces Fz. The sum of these forces will be called the axial force Fa with the units in kN (Figure 3.1).

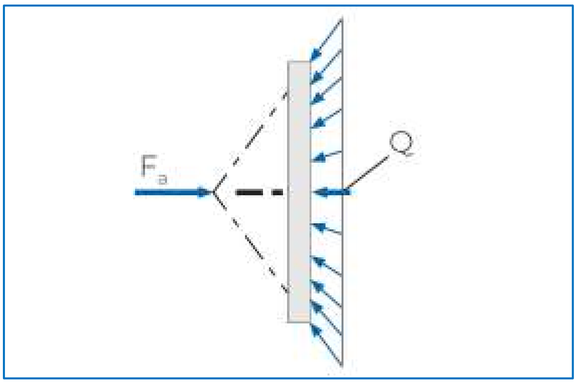


Figure 3.1. – Axial force

3.1.2. RADIAL FORCE

Forces acting in the direction perpendicular to the axis of rotation “z” are called radial forces Fx and Fy. The sum of these forces will be called the radial force Fr, with the units in kN (Figure 3.2).

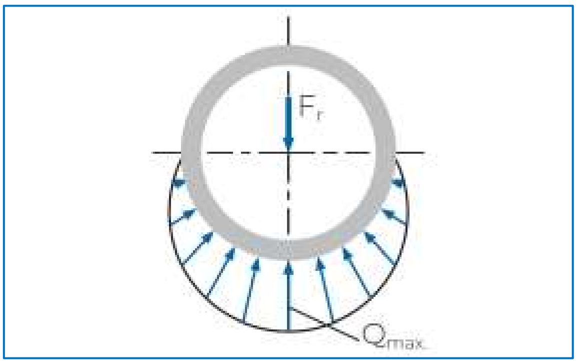


Figure 3.2. – Radial force

3.1.3. TILTING (OVERTURNING) MOMENT

Axial force Fa with the axis not collinear to the axis of rotation “z” forms a resulting tilting (overturning) moment Mk, with the units in kNm (Figure 3.3).

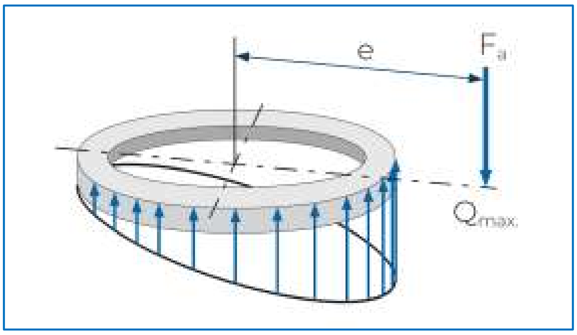


Figure 3.3. – Resulting tilting moment

3.1.4. ROTATIONAL MOMENT (TANGENTIAL FORCE)

The radial force Fr with the axis not crossing the centre of origin "O", also called tangential force Ft, with units in kN, forms a rotational moment or torque Mt, with units in kNm (Figure 3.4). The rotational moment is formed by the mass moment of inertia of the load and of the superstructure. Either the value of the tangential force Ft or the value of the torque Mt, along with the essential data for the pinion gear, is needed in the case of designing slewing bearings with a gear.

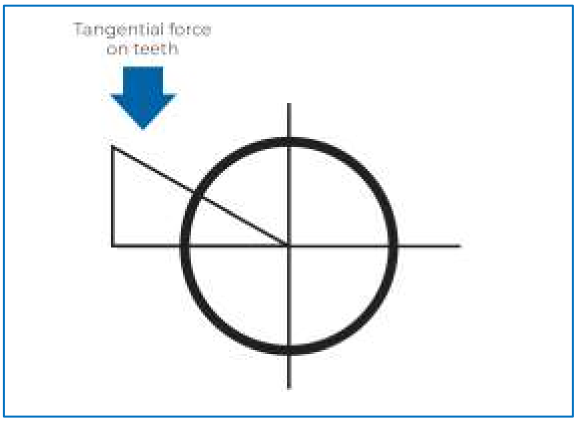


Figure 3.4. – Tangential force

3.1.5. FRICTIONAL ROTATIONAL RESISTANCE

The internal tangential forces opposing the rotation of the slewing bearing are caused by the internal friction of its components. The internal friction can be caused by a preload (in case of slewing bearings with negative clearance), integral seals, viscous friction and the rolling friction of the rolling elements in contact with the raceway and the spacers. The sum of these friction components represents a frictional rotational resistance or bearing friction torque M_{ft}. In the case of loaded bearings, the majority of the frictional rotational resistance is caused by the rolling friction of the rolling elements. Rotational resistance data provided on drawings or otherwise does not include the rolling resistance caused by the load and is always measured on the external connection bolts' diameter unless stated otherwise, with the units in Nm and with a tolerance of ±30%.

3.2. QUESTIONNAIRE

In case of specific application requirements or the need for an optimized large slewing bearing the following questionnaire applies. Optimization of the final product depends on the information given, therefore please fill in the questionnaire below (Table 3.1) as much as possible. It must be pointed out that in case the specified loads are without application factors, the type of application must then be stated.

Table 3.1. – Questionnaire

QUESTIONNAIRE

• CUSTOMER

Company:______________________
Contact:______________________
Telephone:______________________
Email:______________________
Date of inquiry:______________________

• APPLICATIONS

Description of application:______________________

Operating environment ☐ Offshore ☐ Onshore ☐ Mining ☐ Other:________
☐ Vertical ☐ Horizontal ☐ Variable -from:________ -to:________

Temperature range: Min.: [ ] °C Max.: [ ] °C

Type of motion: ☐ Continuous rotation ☐ Oscillation
Preferable type of bearing: ☐ 2000 ☐ 3000 ☐ 4000 ☐ 5000 ☐ 7000

• BEARING SHAPE

Sealing: ☐ On top ☐ At the bottom
Sealing type: ☐ Contact seal ☐ Labyrinth seal
Centering: ☐ Inner ring ☐ Outer ring

ATTACHMENT BOLT HOLE:

Inner ring: ☐ Through holes ☐ Tapered holes Number of holes:________
Outer ring: ☐ Through holes ☐ Tapered holes Number of holes:________

BEARING GEAR:

Type of gearing ☐ Inner ☐ Outer ☐ Without

Normal module [mm]:________
Number of teeth [/]:________
Pressure angle [°]:________
Helix angle [°]:________
Profile shift coefficient x [/]:________
Tooth surface treatment: ☐ Hardened ☐ Ground

Tip alteration k.m [mm]:________
Facewidth [mm]:________
Quality (ISO 1328):________
Reference profile:________
Tooth thickness deviation:________

PINION/S:

Number of pinions [/]:________
Number of teeth of pinion [/]:________
Profile shift coefficient x [/]:________
Facewidth [mm]:________
Tooth surface treatment: ☐ Hardened ☐ Ground

Angle/s between pinions [°]:________
Quality [ISO 1328]:________
Tooth thickness deviation:________
Material of pinion [/]:________

- Page 1 of 2 -

PREFERABLE DIMENSIONS OF THE BEARING:

Outer diameter [mm]: Min.:______________ Max.:______________
Inner diameter [mm]: Min.:______________ Max.:______________
Height [mm]: Min.:______________ Max.:______________

• LOAD SPECIFICATION:

STATIC LOADS:

Load type	Normal	Maximal/Extreme
Fz [kN] (Axial force)		
Fy [kN] (Radial force)		
Fx [kN] (Radial force)		
My [kNm] (Tilting moment)		
Mx [kNm] (Tilting moment)		
Mz [kNm] (Torque)		

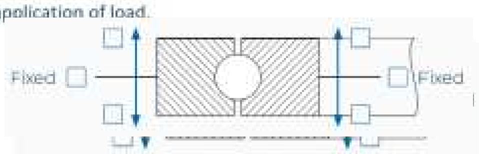
DYNAMIC LOADS:

Load type	1	2	3	4	5	6	7	8	9	10
Fz [kN] (Axial force)										
Fy [kN] (Radial force)										
Fx [kN] (Radial force)										
My [kNm] (Tilting moment)										
Mx [kNm] (Tilting moment)										
Mz [kNm] (Torque)										
*Rotating speed [r/min]										

*-note: if bearing is oscilating, define oscilation speed instead of rotating speed.

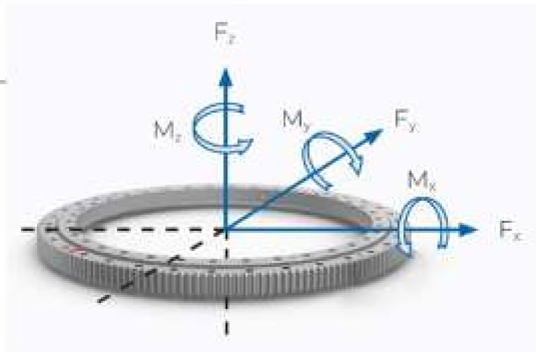
APPLICATION OF LOAD:

Please mark fixed ring and application of load.



BEARING OPERATING TIME:

Operating time [h/day]:______________________



• BEARING REQUIREMENTS

Desired lifetime of the bearing [h]:______________

Desired static safety factor
for max./extreme static load [/]:______________

Desired rotating torque of
unloaded bearing [kNm]:______________

4. INSTALLATION AND APPLICATION

4.1. GENERAL

Slewing bearings are delicate and precise machine elements, therefore strict standards apply during their handling, installation and maintenance.

4.2. PREPARATION FOR THE INSTALATION OF THE SLEWING BEARING

The bearing is normally wrapped in anti-corrosive paper and foil, so the package must be carefully cut and removed so that the seals, surface coating etc., are not damaged. In case of any damage to the product please consult the manufacturer.

Prior to installation, the contacting surfaces and gear teeth must be cleaned at least of any anti-corrosive solvents, remains of grease or any other impurities. Only cleaning solvents and cloths, which do not damage the slewing bearing, i.e. seals, surface coating, etc., can be used. Slewing bearings must never be washed with high pressure washers. During cleaning, no impurities must be allowed to penetrate into the raceway system.

4.3. PREPARATION OF THE ADJACENT MOUNTING STRUCTURES

4.3.1. CLEANING

Prior to installation, the connecting surfaces on the mounting structure must be cleaned of any anti-corrosive solvents, the remains of grease, paint, welding burrs or beads or any other particles.

4.3.2. SURFACE ROUGHNESS

The recommended surface roughness of the connecting surfaces on the mounting structure is between Ra = 3.2μm and Ra = 6.3μm. Inappropriate surface roughness can cause embedding of the contact surfaces, which affects the pretension of the bolts.

4.3.3. THE PERMISSIBLE DEVIATION OF THE CIRCUMFERENTIAL AND RADIAL FLATNESS OF THE CONTACTING SURFACES

Any non-flatness of the contacting surfaces on the mounting structure significantly effects the contact load distribution on the raceways and rolling elements. Deviation from the prescribed flatness tolerance will result in undesirable contact load peaks, which might lead to the premature damage and wear of the raceways. In the case of a geared ring the non-flatness of the contacting surfaces can also significantly reduce the contact surface on the teeth flanks, which can lead to the premature wear of the teeth.

A maximum flatness deviation in the circumferential direction can appear only twice per 360° (one absolute maximum and one absolute minimum). No sudden changes in flatness are allowed. The changes must be gradual and in the shape of a single sine wave as shown in Figure 4.1 and in Figure 4.2. The values for the maximum permissible flatness deviation including the radial deviation with regard to the rolling element type and raceway track diameter are given in Table 4.1. The maximum permissible flatness deviation in the radial direction is basically one half of the permissible flatness deviation in the circumferential direction.

Table 4.1. – Maximum allowed axial deflection of the supporting surface at the maximum operational load

Run diameter (DL) [mm]	Reliable planned run-out error of each support surface	
	Double-row ball bearing supported slewing ring	Single-row ball bearing supported slewing ring
900	0,16	0,12
up to 1300	0,2	0,16
up to 2000	0,3	0,2
up to 3000	0,35	0,25

Run diameter [mm]	Maximal bend [mm]
900	0,5
up to 1300	0,7
up to 2000	0,9
up to 3000	1,5

In Table 4.1 there is defined the maximum permitted axial deflection of the supporting surface at the maximum operational load. These recommendations should not be exceeded.

Table 4.2. – Maximum permissible flatness deviation (including radial flatness deviation)

Raceway track diameter [mm]	Maximum permissible flatnes deviation [mm]	
	Ball bearing (1)	Roller bearing
< 500	0,10	0,08
> 500 ≤ 1000	0,13	0,10
> 1000 ≤1500	0,16	0,12
> 1500 ≤ 2000	0,19	0,14
> 2000 ≤ 2500	0,22	0,16
> 2500 ≤ 3000	0,26	0,18
> 3000 ≤ 3500	0,29	0,19
> 3500 ≤ 4000	0,32	0,21
> 4000 ≤ 4500	0,35	0,23

1) - In case of preloaded bearing the values for roller bearing must be respected

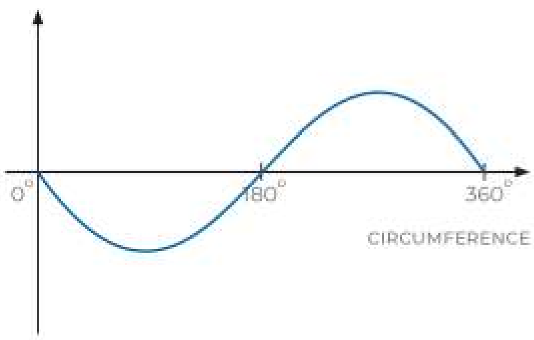


Figure 4.1. – Circumferential and radial flatness deviation of adjacent mounting flange surfaces on sub- and super-structures

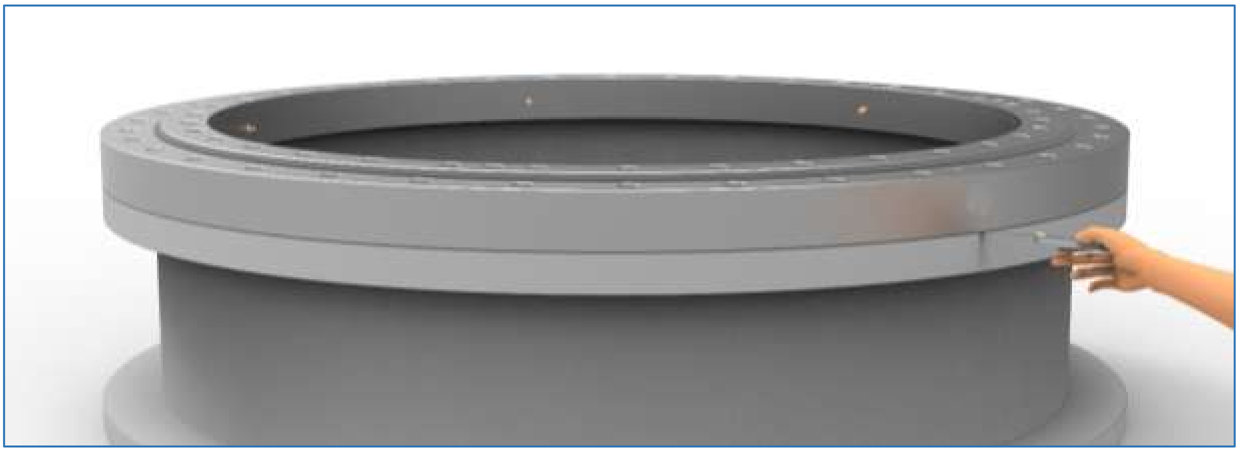


Figure 4.2. – Inspection of flatness deviation around the circumference

4.4. PERMISSIBLE DEFORMATION OF THE MOUNTING STRUCTURE

Figure 4.3. – Flange thickness definition

An important factor for the proper operation of the slewing bearing is the rigidity of the mounting structure. Its excessive deformation under operating load can severely affect the performance and lifetime of the slewing bearing. To minimize such deformations the mounting structure of the bearing must be properly designed and sufficiently rigid. The contacting surfaces of the bearing must always be fully supported by the adjacent contacting surfaces of the mounting structure.

Structural deformations of the contacting surfaces on the mounting structure under maximum load must not exceed 2.5 times the values for the permissible flatness deviation as given in Table 4.2.

In order to ensure a sufficient rigidity of the mounting structure, the minimum thickness of the contacting flanges (Figure 4.3) on the mounting structure must be as given in Table 4.3.

Table 4.3. – Minimum flange thickness in relation to the track diameter

Raceway track diameter [mm]	Minimum flange thickness [mm]	Raceway track diameter [mm]	Minimum flange thickness [mm]
<500	25	> 2000 ≤ 2500	65
> 500 ≤ 750	30	> 2500 ≤ 3000	80
> 750 ≤1000	35	> 3000 ≤ 3500	90
> 1000 ≤ 1250	40	> 3500 ≤ 4000	100
> 1250 ≤ 1500	45	> 4000 ≤ 4500	110
> 1500 ≤ 2000	55		

4.5. POSITIONING OF THE SLEWING BEARING

4.5.1. SOFT SPOT

Standard slewing bearings raceways are induction hardened using a scanning method. Therefore each ring contains a so-called soft spot or hardness gap, a part of the raceway between the start and the end of the quenching path, that is left unhardened.The position of the soft spot is located on each ring at the marking with a stamped letter “M” painted red (alternatively “S”), or at the position of the filling plug, the position where the rolling elements are inserted into the raceway. The bearing must always be positioned in such a way that the soft spot is located at the least loaded zone (Figure 4.4).

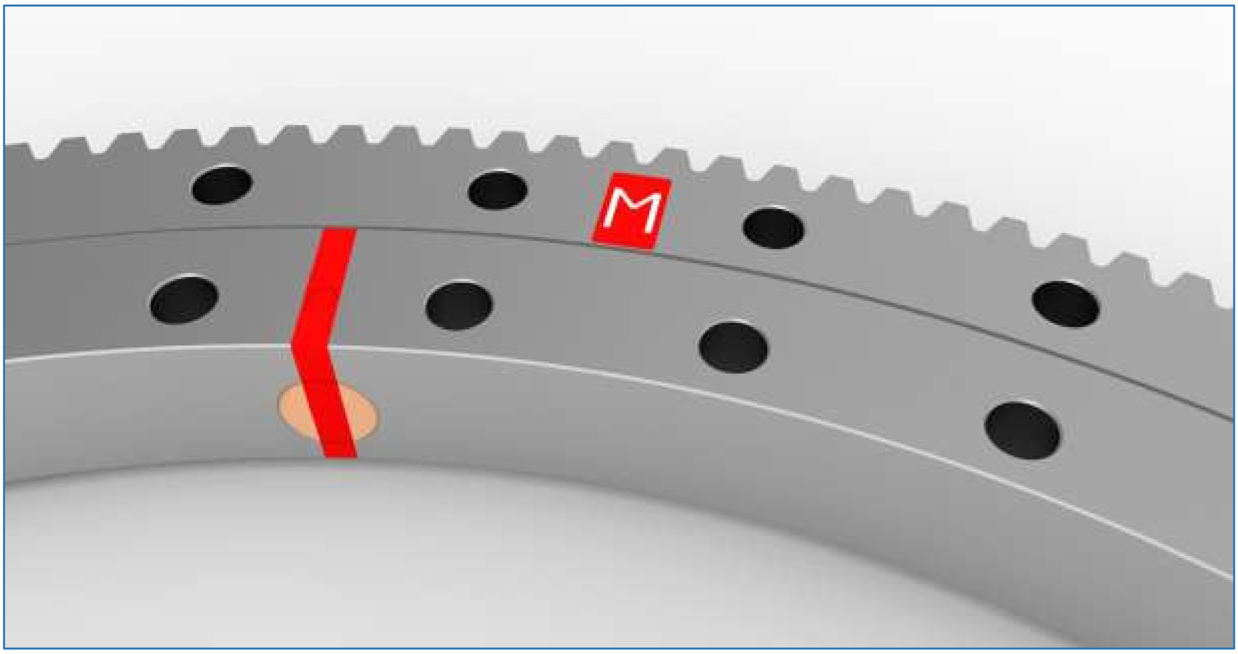


Figure 4.4. – Identification of soft spots on the inner and outer ring

4.5.2. GEAR RINGS

For the proper operation of the gear pair the appropriate backlash between the bearing gear and the pinion gear must be set. Due to the certain ovality of the gear rings, the backlash must be set on the tooth with the largest run-out. Three teeth are marked with a green colour, the middle tooth being the one with largest run-out. If the bearing is driven by more than one pinion the appropriate backlash must be checked and adjusted at each pinion separately. The correct backlash/centre distance must be set by adjusting the position of the pinion, or alternatively, if this is not possible, by repositioning the bearing.

The recommended amount of circumferential backlash is between 0.03×m and 0.04×m [mm], where m stands for the normal module in millimetres. Failure to conform to these recommendations can severely impair the gear and pinion and may lead to the premature wear of the teeth and/or failure of the bearing.

Before mounting the bearing make sure that the coaxiality of the slewing bearing and pinion axes is assured. Failure to comply with this requirement can result in a highly uneven contact distribution between the teeth flanks, which can significantly reduce the performance, the capacity and the lifetime of the slewing bearing.

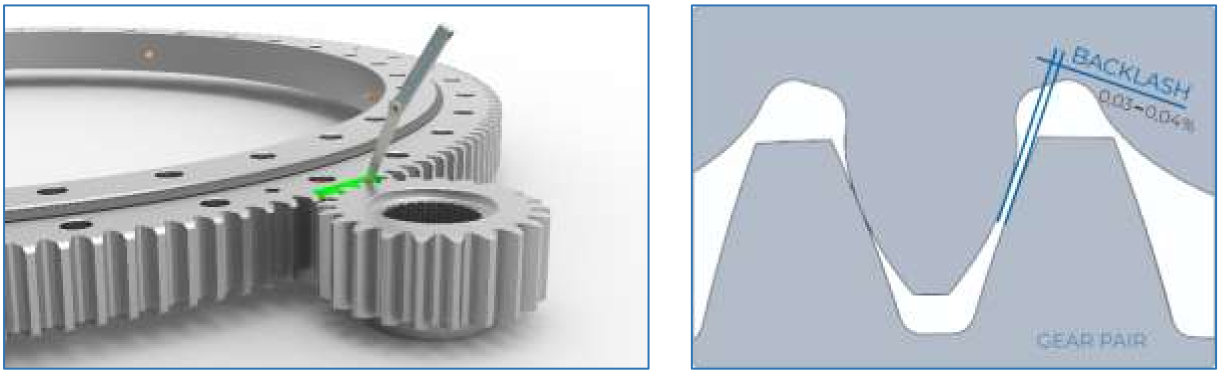


Figure 4.5. – Backlash adjustment

4.6. PRECISION / TOLERANCES

The general tolerances of standard slewing bearings are defined according to standard ISO 286-1 and ISO 286-2. For use entailing higher precision requirements such as industrial robots, radar systems, etc., a higher degree of quality can be achieved. The tolerance values are evaluated according to the design of the slewing bearing. For slewing bearings with larger diameters and smaller cross sections as well as for lower radial rigidity, these values must be considered when mounting on the connecting structure in order to guarantee radial run-out.

Table 4.4. – General tolerances (in compliance with ISO 286-2)

Diameter [mm]													
Diameter [mm]	from:	180	250	315	400	500	630	800	1000	1250	1600	2000	2500
	to:	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150
Inner centering H9 (in µm)		+150	+130	+140	+155	+175	+200	+230	+260	+310	+360	+440	+540
Outer centering f9 (in µm)		-50	-56	-62	-68	-76	-80	-86	-98	-110	-120	-130	-145
		-165	-185	-202	-223	-251	-280	-280	-358	-420	-490	-570	-685
Diameter Js10 (in µm)		±92	±105	±115	±125	±140	±160	±180	±210	±250	±300	±350	±430
Diameter Js13 (in µm)		±0,36	±0,405	±0,445	±0,485	±0,55	±0,625	±0,70	±0,825	±0,975	±1,15	±1,4	±1,65

4.6.1. GEOMETRY

The following criteria must be adhered to:

- all diameters: Js13
- all external centrings: f9
- all internal centrings: H9
- Total height: ± 1mm

4.6.2. FIXATION

The pitch circle diameters must fall within class Js10 and have a minimum tolerance of ± 0.2mm.

4.7. BOLTS

4.7.1. GENERAL

Fastening the slewing bearing on the adjacent mounting structure is established by means of preloaded bolts. The amount of preload on the bolts needed depends on the loads, the number of bolts, geometry, friction between the contacting elements, type of tightening procedure etc. The general recommendations regarding fasteners and tightening the bolts are given in the sections below.

4.7.2. CHOICE OF FASTENERS

Always use new and undamaged fasteners of appropriate quality and design. Nuts and bolts should be of strength class 10.9 (10) according to standard EN 20898. The height of a nut should be at least 1·d, where d is the nominal diameter of the thread. Never use bolts with a fully threaded shaft. The clamping length should be between 5·d to 10·d. The minimum lengths of a thread inserted in a blind threaded hole with a standard ISO metric thread for different materials are given in Table 4.5. The bolt should have at least 6 free threads available in the loaded section of the bolt. If the permissible surface pressure under the bolt is exceeded, an appropriate washer must be used. The permissible static surface pressures for different materials are given in Table 4.6. Mounting structures must be made of steel quality S355 (used as a default for calculations if not specified otherwise) or stronger. The thickness of the washer must be adjusted to the diameter of the bolt and the plane-parallelism must be observed. Never use split rings, spring washers or washers that have softer material. Use only hardened and tempered washers. In case of shock loads or vibrations, the use of bolt lock washers, safety nuts or a product to prevent the threaded connections from coming loose, is recommended. Always make sure that the mounting surface under the bolt or nut head has appropriate straightness and flatness and that the perpendicularity between the bolt/nut axis and supporting surface is assured.

Table 4.5. – The minimum length of thread inserted in a blind threaded hole with a standard metric thread acc. to ISO 68 (tolerance class 6H)

Material of mounting structure	Bolt strength class / diameter	
	10.9	
	≤ M30	> M30
S355	1.25·d	1.4·d
C45N, 42CrMo4N	1.0·d	1.25·d
C45V, 42CrMo4V	0.9·d	1.0·d

Table 4.6. – Permissible static surface pressures

Material of mounting structure	Permissible static surface pressure [MPa]
S355, C45N, 42CrMo4N	600
C45V, 42CrMo4V	800

4.7.3. INSTALLATION FUNCTION

In order to transfer the aforementioned forces, an adequately dimensioned mechanical method of installing the slewing ring onto the corresponding framework must be defined so that the slewing ring remains permanently and firmly fixed to the adjacent structures.

A number of installation methods are possible with the most reliable being the connection with nuts and bolts. Welding methods are absolutely unreliable. The correct usage of the bolt method of installation and its expert execution will determine the correct functioning of the slewing bearing, ensuring safety during its operation.

4.7.4. QUALITY OF THE BOLT CONNECTION

The standard ISO 898-1 defines the quality classes of bolt connections for assembling constructions such as slewing rings. Rotis recommends the quality class 10.9 bolts.

In exceptional situations and in consultation with our design department, the quality classes 8.8 or 12.9 can be used.The nuts must correspond or be a higher quality than the bolts used. For bolts with a diameter of d, nuts with a length of 1 x d are recommended.

Hexagonal bolts are recommended over cylinder screws whenever possible. Rotis recommends using paired and pre-lubricated screw sets (screw + nut) with guaranteed mechanical characteristics (see Table 4.7) so that a more constant coefficient of friction is present.

Table 4.7. – Minimal mechanical characteristics

Strength class (ISO 898)	Tensile strength [MPa]	Yield point [MPa]	Fatigue limit [MPa]	
8.8	800	640	46	**Exception**
10.9	1040	940	46	**Recommended**
12.9	1220	1100	46	**Exception**

4.7.5. CALCULATING THE INSTALLATION METHOD

The calculation rules have been designed by Rotis so that all valid standards and rules, as well as the numerous results from research and testing, are taken into consideration. These calculations are especially based on the VDI–Guideline 2230 (1988)

One must distinguish between overlying and suspended loads, see Figure 4.6. Rotis must be consulted regarding suspended loads, due to the tensile loads in the bolts. The calculation prepositions are:

- Overlying loads act as compressive forces on the bolts.
- The bolts are placed evenly over the circumference of the pitch circle.
- Slew rings and connecting sub- and super-structure flanges are made of steel S355.
- Slew rings according to the proposed: thickness, rigidity and parallelity.
- Centring grooves are used to avoid shearing loads on the bolts in case large radial forces are present.
- The length of the screw connection is at least equal to five times the thread diameter: LK ≥5 x d.

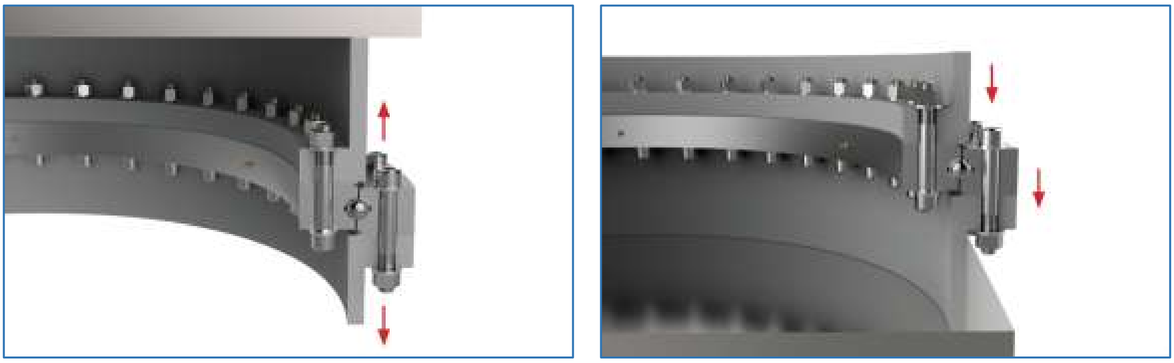


Figure 4.6. – Suspended (left) and Overlying (right) construction

4.7.6. BOLTS TIGHTENING PROCEDURE

Before tightening make sure that the claims and recommendations given in the previous sections are taken into account. Only use an appropriate torque wrench or a hydraulic bolt-tensioning cylinder for tightening. Never use an impact screwdriver.

If not stated otherwise, limiting load charts are calculated for a 70% utilization of the bolt yield strength. On request the utilization of the bolt yield strength can be optimized.

The clamping forces and tightening torques for a torque wrench and a hydraulic bolt-tensioning cylinder are given in Table 4.8., 4.9. and 4.10. The values are calculated according to VDI 2230 for standard bolts with a hexagonal head according to ISO 4014 and standard metric coarse threads, strength class 10.9, coefficients of friction between the bolt head and the mounting surface, and between the threads $\mu K \approx \mu G \approx 0.14$. Since the estimation of the friction coefficients for bolts with a larger diameter is not precise enough, for threads above M30 only the values for clamping forces are given. Bolts with threads larger than M30 should be tightened by means of a hydraulic bolt-tensioning cylinder. When using the hydraulic bolt-tensioning cylinder strictly follow the instructions provided by its manufacturer. The preloading of a bolt must never exceed 90% of its yield strength.

In the case of geared rings, the non-geared ring must be fastened first. Before tightening, the threads should be lightly oiled. Bolts must be tightened in 3 steps at least in a cross-wise order as shown in Figure 4.6. For example, in the first step the bolts should be tightened to approximately 30%, in the second step to approximately 80% and in the last step to 100% of the required clamping force or tightening torque. During each step the bearing should be rotated few times.

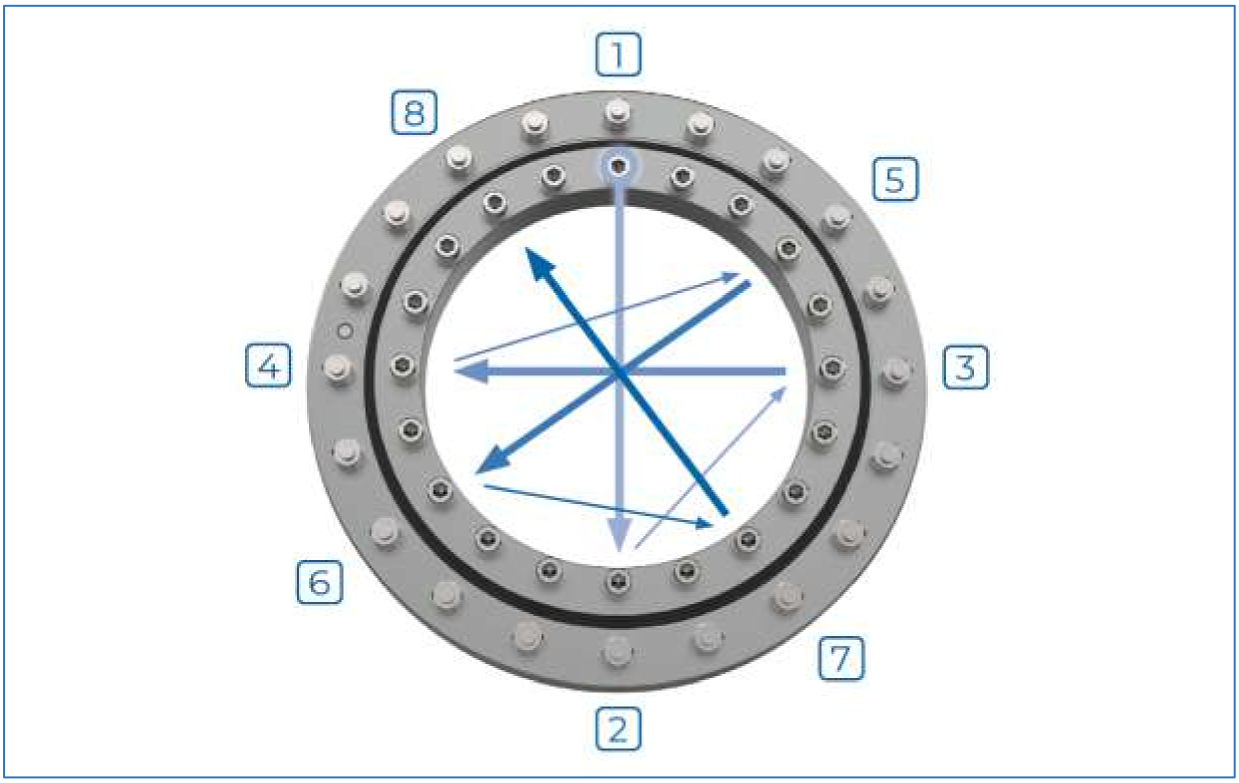


Figure 4.7. – Cross-wise tightening procedure of bolts

During the operation of the bearing the bolts should be regularly checked. For further information regarding this please refer to section 6.1.2.2.

Table 4.8. – Clamping forces and tightening torques for standard ISO 4014 bolts - class 8.8 with defined preload

Metric thread size (coarse pitch)	Clamping force F_M [kN] (Preload defined in %)			Tightening torque (for torque wrench) $M_{A\ max}$ [Nm] (Preload defined in %)		
	70%	**80%**	**90%**	**70%**	**80%**	**90%**
M10	22.4	25.6	28.8	42.1	48.1	54.2
M12	32.6	37.3	41.9	72.7	83.1	93.5
M14	44.8	51.2	57.6	115.7	132.2	148.8
M16	61.3	70.1	78.9	179.4	205.1	230.7
M18	77.2	88.2	99.2	257.0	293.7	330.4
M20	98.9	113.0	127.1	362.7	414.5	466.3
M22	123.3	140.9	158.5	495.8	566.7	637.5
M24	142.4	162.7	183.1	623.3	712.3	801.4
M27	186.9	213.6	240.3	918.2	1049.4	1180.5
M30	227.4	259.9	292.4	1247.0	1425.1	1603.2
M33	282.9	323.3	363.7	1686.7	1927.6	2168.6
M36	332.3	379.8	427.2	2168.5	2478.3	2788.1
M39	398.7	455.6	512.6	2809.3	3210.6	3611.9
M42	457.0	522.2	587.5	3469.9	3965.6	4461.3
M45	534.3	610.6	686.9	4331.2	4949.9	5568.6
M48	601.4	687.4	773.3	5242.0	5990.9	6739.8
M52	720.4	823.3	926.3	6732.2	7694.0	8655.8
M56	831.2	949.9	1068.7	8394.3	9593.4	10792.6
M60	970.1	1108.7	1247.2	10407.5	11894.2	13381.0

Bolt: ISO 4014 - class 8.8
Standard metric coarse thread
Coeff. of friction: μK≈μG≈0.14
Preload is in % of yield stress

Table 4.9. – Clamping forces and tightening torques for standard ISO 4014 bolts - class 10.9 with defined preload

Metric thread size (coarse pitch)	Clamping force F_M [kN] (Preload defined in %)			Tightening torque (for torque wrench) $M_{A\,max}$ [Nm] (Preload defined in %)		
	70%	**80%**	**90%**	**70%**	**80%**	**90%**
M10	32.9	37.6	42.3	61.9	70.7	79.6
M12	47.9	54.8	61.6	106.8	122.1	137.3
M14	65.8	75.2	84.6	170.0	194.2	218.5
M16	90.1	103.0	115.9	263.6	301.2	338.9
M18	109.9	125.6	141.3	366.0	418.3	470.6
M20	140.8	161.0	181.1	516.6	590.4	664.2
M22	175.6	200.7	225.7	706.2	807.1	908.0
M24	202.8	231.8	260.8	887.7	1014.6	1141.4
M27	266.2	304.2	342.3	1307.7	1494.6	1681.4
M30	323.9	370.2	416.5	1776.0	2029.7	2283.4
M33	402.9	460.5	518.0	2402.2	2745.4	3088.6
M36	473.3	540.9	608.5	3088.5	3529.7	3970.9
M39	567.8	648.9	730.0	4001.1	4572.7	5144.3
M42	650.8	743.8	836.8	4942.0	5648.1	6354.1
M45	760.9	869.6	978.4	6168.6	7049.9	7931.1
M48	856.6	979.0	1101.4	7466.0	8532.5	9599.1
M52	1026.1	1172.6	1319.2	9588.4	10958.1	12327.9
M56	1183.8	1352.9	1522.0	11955.5	13663.4	15371.3
M60	1381.6	1579.0	1776.4	14822.8	16940.3	19057.9

Bolt: ISO 4014 - class 10.9
Standard metric coarse thread
Coeff. of friction: $\mu K \approx \mu G \approx 0.14$
Preload is in % of yield stress

Table 4.10. – Clamping forces and tightening torques for standard ISO 4014 bolts - class 12.9 with defined preload

Metric thread size (coarse pitch)	Clamping force F_M [kN] (Preload defined in %)			Tightening torque (for torque wrench) $M_{A\ max}$ [Nm] (Preload defined in %)		
	70%	**80%**	**90%**	**70%**	**80%**	**90%**
M10	38.5	44.0	49.5	72.4	82.8	93.1
M12	56.1	64.1	72.1	125.0	142.8	160.7
M14	77.0	88.0	99.0	198.9	227.3	255.7
M16	105.5	120.5	135.6	308.4	352.5	396.6
M18	128.6	147.0	165.4	428.3	489.5	550.7
M20	164.8	188.4	211.9	604.5	690.9	777.3
M22	205.5	234.8	264.2	826.4	944.5	1062.6
M24	237.3	271.3	305.2	1038.8	1187.3	1335.7
M27	311.5	356.0	400.5	1530.3	1749.0	1967.6
M30	379.1	433.3	487.4	2078.3	2375.2	2672.1
M33	471.5	538.8	606.2	2811.1	3212.7	3614.3
M36	553.9	633.0	712.1	3614.2	4130.5	4646.8
M39	664.5	759.4	854.3	4682.2	5351.0	6019.9
M42	761.6	870.4	979.3	5783.2	6609.4	7435.6
M45	890.5	1017.7	1144.9	7218.6	8249.9	9281.1
M48	1002.4	1145.6	1288.8	8736.8	9984.9	11233.0
M52	1200.7	1372.3	1543.8	11220.4	12823.4	14426.3
M56	1385.3	1583.2	1781.1	13990.5	15989.1	17987.8
M60	1616.8	1847.8	2078.8	17345.8	19823.8	22301.7

Bolt: ISO 4014 - class 12.9
Standard metric coarse thread
Coeff. of friction: μK≈μG≈0.14
Preload is in % of yield stress

4.7.7. MEASURING THE INITIAL TILTING CLEARANCE AND AXIAL SETTLING

Due to the wear of the raceways during operation, the tilting clearance and axial settling (axial reduction of bearing height) of the bearing increase. Hence, in order to correctly track the changes of these two parameters throughout the bearing's lifetime they must be measured prior to putting the bearing into operation. All subsequent measurements of these two parameters, which have to be done during maintenance work, must be compared to these initially measured values. The measurements must be carried out for each installed slewing bearing.

The measurements can be carried out by using the appropriate dial gauges with an accuracy of at least 0.01mm. The dial gauges will measure the distance between one of the rings and the structure attached to the opposite ring as shown in Figure 4.8.

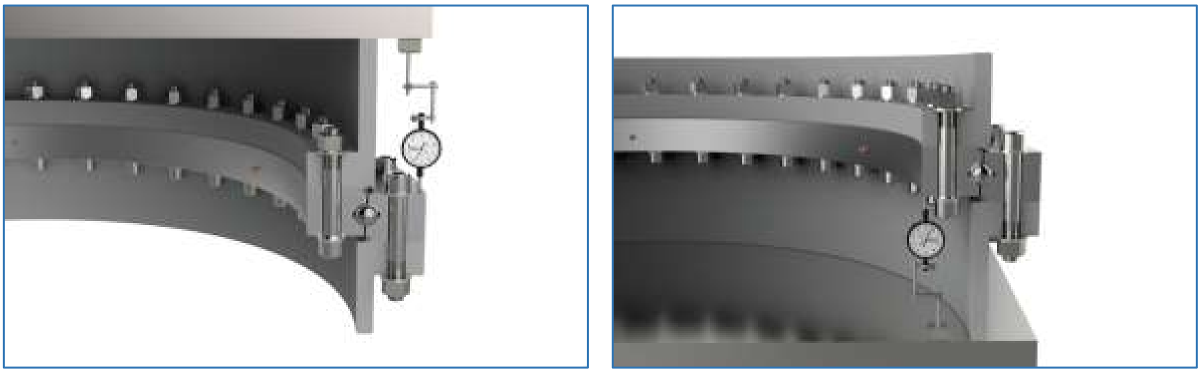


Figure 4.8. – Measuring of the tilting/axial clearance

Measurements should be carried out at least in 4 points (preferably 8) around the circumference of the bearing. The points should be marked permanently on both rings so that all subsequent measurements can be done at exactly the same measuring points and relative position of the rings. The soft spot should be centred between two consecutive measuring points. In order to minimize the effect of elastic deformation of the system the measurements should be taken as close to the bearing rings as possible.

All subsequent measurements which are performed during regular maintenance work, must be carried out at the same measuring points and using the same measuring procedures and loads as those used during the initial measurements.

5. OTHER IMPORTANT FEATURES

5.1. TEMPERATURE RANGE

The temperature range for the operation of standard slewing bearings is between -25°C and +70°C. For other temperature ranges a custom design can be requested.

5.2. ROTATIONAL SPEED

The maximum rotating speed of large slewing bearings is limited due to the soft spot on the raceway. The maximum reliable circumferential speed for four point contact ball and roller bearings (Type 2000, 3000, 5000 and 7000) up to 2m/s, and short-term up to 2.8m/s.

Figure 5.1. – Rotational speed

Type of bearing	Max. speed [m/s]	Max. speed (short-term) [m/s]
2000	4	5.5
3000	2	2.8
5000	2	2.8
7000	2	2.8

5.3. IMPACT, VIBRATIONS

When slewing rings are subjected to constant impacts or vibrations it must be stated at the time of the quotation to ensure that the design department takes this into account when designing the slewing bearings.

6. MAINTENANCE, INSPECTION AND STORAGE

6.1. MAINTENANCE

6.1.1. GENERAL

Each maintenance task must be properly recorded and documented. Any deviation from the expected values must be checked and verified by a responsible specialist and, if needed, communicated to Rotis.

6.1.2. MAINTENANCE SCHEDULE

In order to assure the optimal performance of the slewing rings, regular maintenance must be carried out. The maintenance work and the maximum maintenance intervals are given in Table 6.1. In case increased wear, i.e. increased tilting clearance or axial settling, is noticed, the intervals should be shortened accordingly.

A detailed description of each maintenance task is given in the next section.

Table 6.1. – Maintenance schedule

Maintanance task	Maximum maintanance interval
Relubrication	**Automatic:** • Before operation • Weekly or daily Every 6 months check and empty grease collection bottles if needed[1)] **Manual:** • Before operation • Every 3 months
Checking of bolts	3 months after mounting, after that every 12 months and after every longer standstill or extreme load
Checking of seals	3 months after mounting, after that every 6 months and after every longer standstill or extreme load
Tilting clearance and settling	3 months after mounting, after that every 12 months and after every longer standstill or extreme load

1) - maximum interval for checking and emptying grease collection bottles must be adjusted to the amount of grease added during the lubrication procedure and volume of grease collecting bottles.

6.1.2.1. BEARING RELUBRICATION

Incorrect lubrication is one of the most common reasons for the premature failure of the bearings. Hence, lubrication of the bearing is one of the most important maintenance tasks, which can significantly prolong its service life. In order to assure good relubrication conditions it is highly recommended to use an automatic relubrication system, which can significantly improve the lubrication of the raceway system or the gear.

At the time of delivery of the raceway system of the slewing bearing should for a standard design be completely filled with grease. This can be tested by checking if during the relubrication process, grease penetrates all the grease exit holes or comes from under the seals around the whole circumference (if applicable). It is highly recommended to verify the amount of grease and the lubrication system (if applicable) during the first run test, i.e. prior to putting the bearing into operation. This is of special importance if the bearing has been stored for a longer period of time.

In addition to the relubrication during regular maintenance tasks, the bearing, i.e. the raceway system and the gear, should also be relubricated in the following cases:

- after dismantling the slewing bearing,
- before and after long periods of inactivity.

Relubrication of the bearing must always be carried out by a skilled and qualified worker.

Relubrication must always be carried out with the original grease specified by the slewing bearing manufacturer or its equivalent. Different greases can be mixed together, however, this must always be verified and confirmed by the grease manufacturer or Rotis. An example of the types of grease used normally are given in Table 6.2 – other greases are also available on request.

Since the relubrication procedure significantly depends on the loading, operating and environmental conditions, the optimal relubrication interval, the amount of grease and other settings for the automatic lubrication system can only be defined through a sufficiently long observation period of actual application. The values given here should only serve as a guide and should only be used if no other empirically verified data is available. It is the responsibility of the slewing bearing end customer to regularly monitor the bearing's performance, grease quality and lubrication procedure, which should serve as a basis for the determination of the optimal parameters for the relubrication procedure.

Table 6.2. – Standard greases for the raceway system and gear

	Manufacturer	Grease name	Operating temperature[1)]
Raceway system	Castrol	Spheerol EPL 2	-20°C to +140°C
	Shell	Gadus S2 V220 2	-20°C to +130°C
	Mobil	Mobilith 220 SHC	-40°C to +150°C
Gear	Castrol	Molub-Alloy OG 9790/2500-0	-20°C to +140°C
	Shell	Gadus OGH NLGI 0	-10°C to +200°C
	Mobil	Mobilgear OGL 461	-20°C to +120°C

1) According to manufacturers specifications

The relubrication procedure must be appropriately recorded and documented. An example of the relubrication protocol form is shown in Table 6.3.

If not specified otherwise, the following should be taken into account during relubrication:

- Before relubricating the raceways, always make sure that the old grease is able to come out of the raceway system. Make sure that the bottles for collecting the old grease are not full and that no overpressure can appear in them during relubrication.
- Before relubricating the gear clean the teeth of any impurities and used grease – especially at the teeth roots.
- Relubrication must always be performed during a full rotation of the bearing with a low to moderate bearing load. The tests carried out during the assembly of the bearings have shown that the rotation speed from 0.5rpm to 1.5rpm results in the appropriate lubrication of the raceway system.
- Relubrication of the raceways must be performed equally at all grease holes, i.e. with the same amount and flow rate of the grease. In case of an automatic relubrication system, an equal distribution of grease must be guaranteed by the lubrication system – it is recommended that the flow rate of the grease does not exceed 50g/min per 1 grease hole. Also refer to the recommendations of the manufacturer of the automatic relubrication system.

If the gear is relubricated manually, the teeth should be sprayed or brushed with grease.

In case of the manual relubrication procedure, relubrication should be performed before operation and at least every 3 months. In such case the quantity of grease must be adjusted according to the in accordance with the Figure 6.1. and Figure 6.2. below.

After relubrication of the raceways, clean any excess grease, which might have come out from under the seals (where applicable). If needed, empty the bottles for collecting used grease (where applicable).

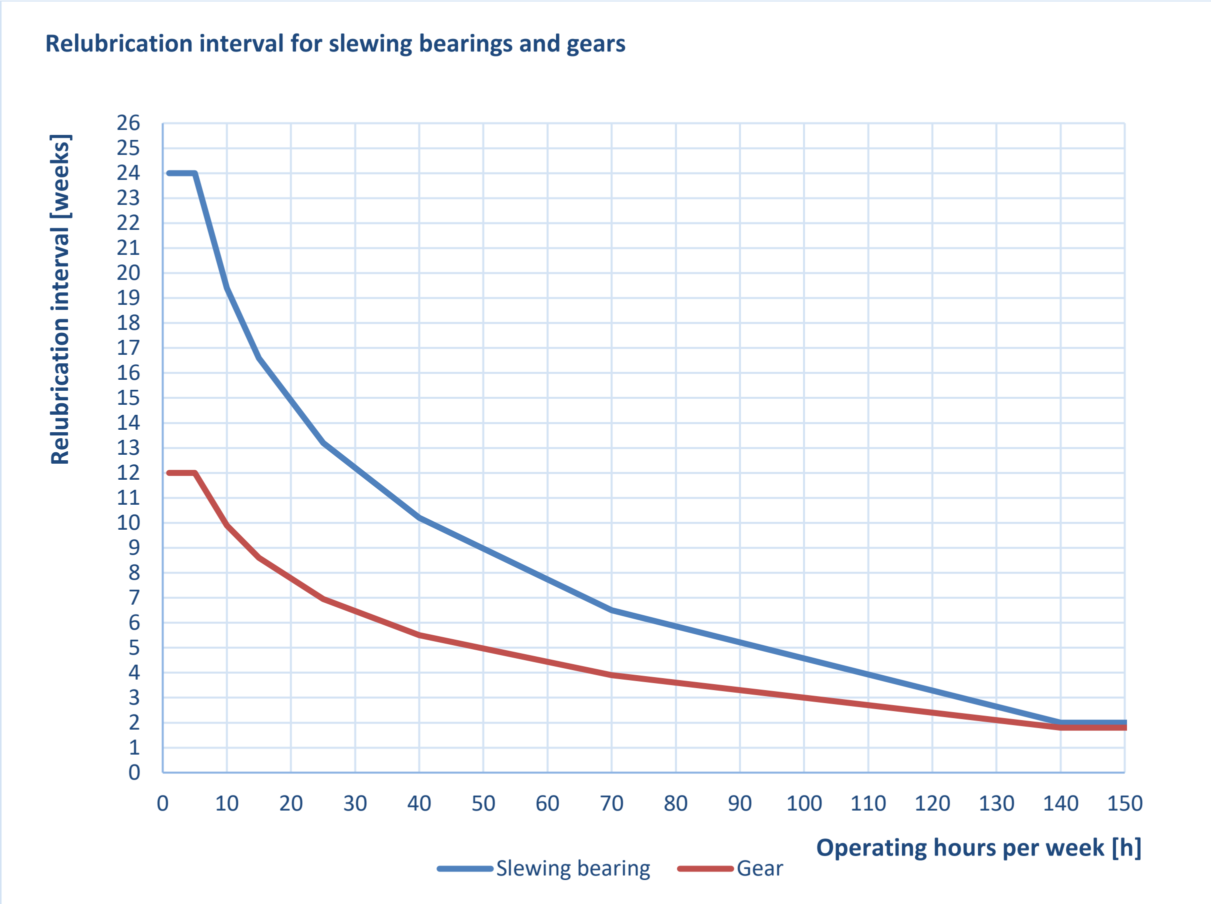


Figure 6.1. – Relubrication interval for slewing bearings and gears

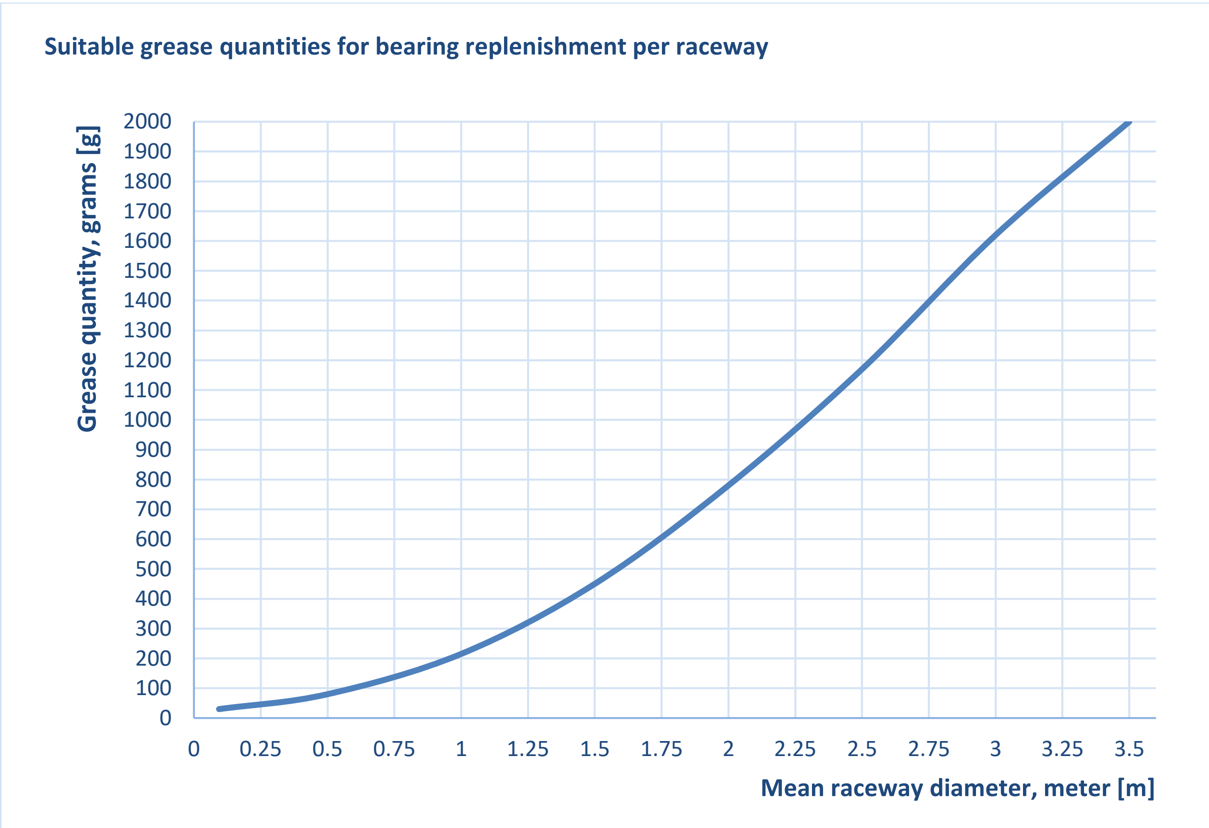


Figure 6.2. – Suitable grease quantities for bearing replenishment per raceway

Table 6.3. – An example of the relubrication protocol for the raceway system/gear

RELUBRICATION PROTOCOL FOR: raceway system / gear	
Document number	
Bearing serial number	
Bearing designation	
Manufacturer	Rotis d.o.o., Brodišče 5, 1236 Trzin, Slovenia
Relubrication data	
Rated grease quantity	[g/week] at rotating speed [min^{-1}]
Remarks	First relubrication before function test

#	Date	Grease type	Grease quantity [g]	Rotating speed [min-1]	Additional checks	Worker/Operator		
						Name	Signature	Comment
1					[ ] Manual relubrication [ ] Automatic relubrication [ ] Clean old grease [ ] Empty grease collecting bottles			

6.1.2.2. BOLTING CONNECTION INSPECTION

The bolts must be checked at least during every scheduled maintenance interval, as given in Table 6.1, or after any exceptionally high and destructive loads.

Bolts must be checked for correct preload. Any detached or loosened bolts, nuts or washers must be replaced with new and undamaged parts of the same size and quality as originally prescribed and used. Always use the same tightening procedure as originally used. For other information regarding tightening bolts refer to section 4.7.6

6.1.2.3. SEALING PROFILES INSPECTION

The integral seals protect the raceway system from the penetration of contaminants and moisture into the system and to prevent grease from exiting. In order to exclude any possibility of defects resulting from environmental factors, the seals must be regularly checked and replaced if needed. Make sure that no objects or any other media get into contact with the seals to ensure there is no mechanical or chemical damage. Please note that due to the function of the seals it is possible that over time they will wear and they must be replaced.

The seals must be checked at least as often as specified in the maintenance schedule given in section 6.1.2 and after standing still for a long time or after extreme loading.

Slewing bearing seals are essentially extruded rubber profiles with glued ends. In order to assure their proper function the seals are also glued to the grooves on the ring.

In case the seal is damaged or worn, replace it immediately. Replacement seals can be ordered from Rotis – in order to identify the correct seal type, specify the bearing / drawing number and serial number of the bearing. Please note that the length of the seal profile has to be cut to the exact length after gluing the seal into the groove – the profile obtained from Rotis will typically be a bit longer than the circumference of the seal groove.

Sealing profile replacement:

When replacing the seal follow the steps described below. Since the glues used for gluing the seals cure in the presence of atmospheric moisture, make sure that the air is not too dry. Additional directions regarding the seal materials, adhesives and other information are given in Table 6.4.

i. Preparation of the seal groove:

- Completely remove the old seal by pulling it out of the groove.
- During cleaning pay special attention so that no foreign objects penetrate the raceway system.
- First use mechanical tools if needed, e.g. a knife with a snap-off blade or other appropriate tool, which does not damage the groove, and completely remove all the remains of the seal that might still be glued into the groove.
- After that thoroughly clean and degrease the groove with an appropriate cloth and a cleaning agent which does not damage the ring. Before proceeding to the next step make sure that the groove is completely dry.

ii. Gluing and inserting the seal into the groove:

- Leave the first 5 to 10cm of the seal untouched – do not glue it into the groove.
- Spread the glue evenly along the ribbed surfaces of the seal profile in a length of approximately 30 to 50cm, as shown in Figure 6.4. Adjust the length to the drying time of the glue and adhere to the recommendations provided by the glue manufacturer.
- Gently push the seal into the groove and make sure that t fits completely into it. Use some smooth blunt object Figure 6.3, like ball-peen hammer, if needed. In order to assure a thorough contact surface between the sealing profile and the groove, additionally position the sealing profile using gentle strokes – use some smooth and blunt object in combination with a ball-peen hammer to fit the sealing profile. Make sure that the sealing profile does not get damaged.

Figure 6.3. – Fitting of the sealing profile

- Repeat the previous two steps until the whole seal – except approximately the last 5cm is glued into the groove.
- Do not glue the last 5cm of the seal.

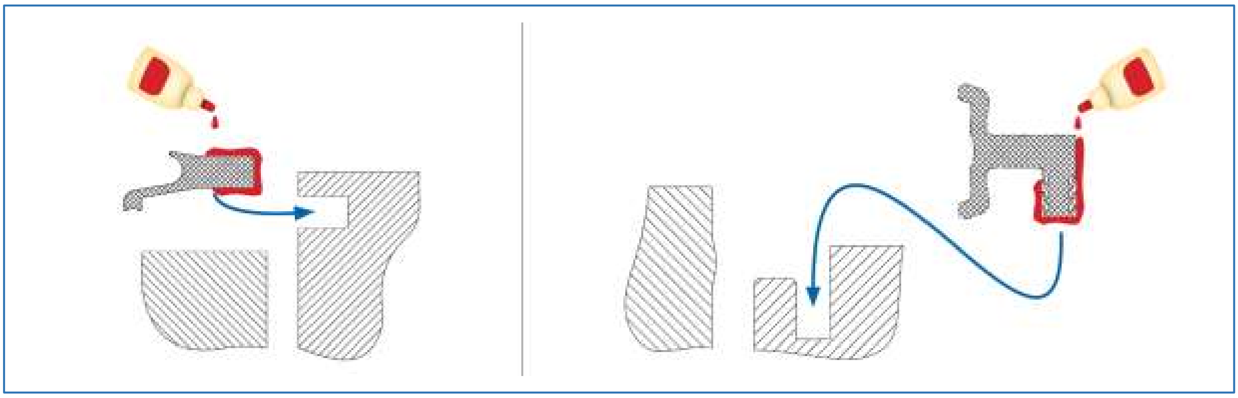


Figure 6.4. – Application of the glue on the sealing profile

iii. Joining the ends of the seal profile:

- Carefully cut the seal profile to the correct length – use a knife with a snap-off blade or a similar tool, and cut it on a hard and plain surface. Make sure that the cut is straight, clean and perpendicular to the seal profile (see Figure 6.5).

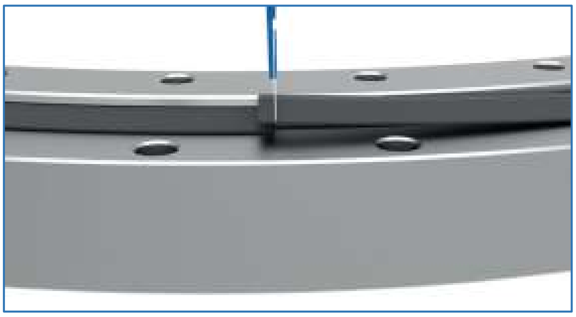


Figure 6.5. – Cutting the sealing profile

- Spread the glue evenly to both ends of the seal profile (Figure 6.6) and press it together for few seconds (if the bond is not sufficiently strong, cut off approximately 1mm of the seal ends and glue it together again).

Figure 6.6. – Application of the glue on the final ends of the sealing profile

- After both ends of the seal profile have been appropriately glued together, spread the glue evenly onto the remaining unglued ribbed surfaces of the seal as shown in Figure 6.7 and carefully fit the remaining seal profile into the groove – refer to the step ii. described above.

Figure 6.7. – Joining the ends of the sealing profile

- Before continuing with the next final steps, hold for the appropriate curing time of the glue – refer to Table 6.4.
- Clean any remains of the glue which might have been squeezed out of the groove while gluing.
- Apply the raceway grease generously onto the contact surfaces of the seal and the ring. To avoid damaging the sealing profile, use an appropriate brush tool.
- If needed, relubricate the bearing – refer to section 6.1.2.1.

Table 6.4. – Additional information regarding seal materials, glues and other information

Seal material	Recommended glue	Additional notes
NBR / VITON	LOCTITE SUPER ATTACK (406, 480)	Only for adhesive both ends of the seal
NBR / VITON	Innotec	Refer to the glue manufacturer instructions **The adhesive must be suitable for bonding rubber to metal**
NBR / VITON	Kemiskol	Refer to the glue manufacturer instructions **The adhesive must be suitable for bonding rubber to metal**
SILICON	WACKER E43	Recommended resumed operation after 24 hours (refer also to the glue manufacturer instructions) **The adhesive must be suitable for bonding elastomer to metal**

6.1.3. MEASURING THE INCREASE IN THE TILTING AND AXIAL CLEARANCE

An increase in clearances is an indicator that the raceways are worn or the bearing rings have become deformed. The tilting and axial clearance must be checked at least during each scheduled maintenance interval as given in Table 6.5. The values measured during the maintenance intervals must be compared to the initial values measured. The actual increase in the tilting or axial clearance is calculated as the difference between the values measured during the maintenance intervals and the initial values:

where:

δ is the increase in the tilting or axial clearance,

V_m is the value measured during maintenance,

V_i is the initial clearance.

The results must be appropriately recorded and documented. For more information regarding the measurement procedure refer to section 4.7.7. The maximum permissible values for an increase in tilting and axial clearance of the slewing bearings are given in Table 6.6. These values must never be exceeded – if reached, the bearing must be replaced immediately.

Table 6.5. – An example of the measurement protocol form for axial settling/tilting clearance

<table>
<tr><th colspan="11">MEASUREMENT PROTOCOL FOR: axial settling/tilting clearance</th></tr>
<tr><td colspan="4">Document number</td><td colspan="7"></td></tr>
<tr><td colspan="4">Bearing designation</td><td colspan="7"></td></tr>
<tr><td colspan="4">Bearing serial number</td><td colspan="7"></td></tr>
<tr><td colspan="4">Manufacturer</td><td colspan="7">Rotis d.o.o., Brodišče 5, 1236 Trzin, Slovenia</td></tr>
<tr><th colspan="11">Measurement results</th></tr>
<tr><td colspan="4">Maximum permissible increase</td><td colspan="7"></td></tr>
<tr><td colspan="4">Symbol explanation</td><td colspan="7">V_i … initial value in [mm],
V_m … measured value in [mm],
$\delta = V_m - V_i$ … increase of tilting clearance/axial settling in [mm]</td></tr>
<tr><td rowspan="2">#</td><td rowspan="2">Date</td><td rowspan="2">Value</td><td rowspan="2">P1</td><td rowspan="2">P2</td><td rowspan="2">P3</td><td rowspan="2">P4</td><td rowspan="2">...</td><td colspan="3">Worker/Operator</td></tr>
<tr><td>Name</td><td>Signature</td><td>Comment</td></tr>
<tr><td>0</td><td></td><td>V_i</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">1</td><td rowspan="2"></td><td>V_m</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>δ</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 6.6. – Permissible increase in tilting clearance and axial settling due to wear of the raceways [mm]

<table>
<tr><th colspan="12">Single and double row 4-contact point ball bearings</th></tr>
<tr><td>Ball diameter</td><td>20</td><td>22</td><td>25</td><td>30</td><td>35</td><td>40</td><td>45</td><td>50</td><td>55</td><td>60</td><td>70</td></tr>
<tr><td>Axial reduction measurement</td><td colspan="4">1.3</td><td colspan="2">1.6</td><td colspan="3">2.1</td><td colspan="2">2.6</td></tr>
<tr><td>Tilting measurement</td><td colspan="4">1.5</td><td colspan="2">2.1</td><td colspan="3">2.6</td><td colspan="2">3.2</td></tr>
<tr><th colspan="12">Double row 2-contact point ball bearings</th></tr>
<tr><td>Ball diameter</td><td>20</td><td>22</td><td>25</td><td>30</td><td>35</td><td>40</td><td>45</td><td>50</td><td>55</td><td>60</td><td>70</td></tr>
<tr><td>Axial reduction measurement</td><td colspan="4">1.4</td><td colspan="2">1.8</td><td colspan="3">2.4</td><td colspan="2">3.0</td></tr>
<tr><td>Tilting measurement</td><td colspan="4">2.0</td><td colspan="2">2.4</td><td colspan="3">3.2</td><td colspan="2">4.0</td></tr>
<tr><th colspan="12">Roller bearings</th></tr>
<tr><td>Roller diameter</td><td>16</td><td>20</td><td>25</td><td>28</td><td>32</td><td>36</td><td>40</td><td>45</td><td>50</td><td>60</td><td>70</td></tr>
<tr><td>Axial reduction measurement</td><td colspan="3">0.4</td><td colspan="3">0.6</td><td colspan="3">0.8</td><td colspan="2">1.0</td></tr>
<tr><td>Tilting measurement</td><td colspan="3">0.7</td><td colspan="3">1.0</td><td colspan="3">1.4</td><td colspan="2">1.8</td></tr>
</table>

6.1.4. CLEANING

Only use cleaning solvents and lint-free cloths which do not damage the bearing, i.e. seals, surface coating, etc. Bearings must never be washed with high pressure washers.

During cleaning, no contaminants must be allowed to penetrate the sealing system. Clean any excess grease which might have come out from under the seals (where applicable).

6.1.5. ANTI-CORROSION PROTECTION

For special types of use, ROTIS can apply a corrosion protector on the surfaces, e.g.:

- Galvanization or galvanization/bichrome treatment
- Phosphate coating
- Chemical nickel plating
- Protective paint coating
- 5. through 9. various treatments such as chromization, high temperature galvanizing, anodic oxidation, etc.,

Consult with the technical department.

6.2. INSPECTION

If an excessive loss of lubricant is observed upon subsequent lubrication, the following should be checked:

- Whether the protective seal is still in place,
- Whether the seal is damaged (cuts, tears, wearing),
- Whether it warrants the functioning of the slewing ring.

Sealing profiles should be reinstalled or replaced accordingly.

6.3. STORAGE

Large slewing bearings must always be stored in a horizontal position on a firm, flat surface. Any impacts or other mechanical vibrations must be prevented. In case of storing in a stack, i.e. one on top of another; appropriate separating elements must be used. A maximum of 3 bearings can be stored in a stack.

The bearing must be stored indoors in a dry and dust –free location and it must not be exposed to direct sunlight. The recommended ambient temperature for storing is between 10°C and 40°C, and the maximum relative humidity should not exceed 65%.

The packaging must be removed just before installation. If stored properly, the preservation of the bearings should last at least approximately 10 months. However, it is recommended that the bearings are used within no less than 2 months. In case of longer storage periods, the packaging should be regularly checked and, if needed, an appropriate corrosion protection solvent should be re-applied.

7. TRANSPORTATION AND HANDLING

7.1. GENERAL

Before, during and after any form of transportation, the customer shall ensure the following:

- The transport shall be carried out only by trained and skilled workers/operators.
- The lifting and transportation of the slewing bearing shall be done with care and attention, avoiding any collisions, excessive accelerations and speeds – and the bearing must not be dropped.
- The equipment used for transportation and handling shall have sufficient lifting and carrying capacity.
- The transportation equipment used for the handling and transportation of the slewing bearing shall be such that it does not damage the bearing, or its packaging.
- Slewing bearings must always be transported with their axis of rotation in a vertical direction and properly supported, so that any deformations are impossible. In the case of larger bearings when a tilted position cannot be avoided, the use of a supporting structure must be used to ensure adequate support, especially in the radial direction.

7.2. BEARINGS ON PALLETS OR IN BOXES/CRATES

Bearings shipped on pallets or in boxes/crates, here referred to as packages, should be transported by using a forklift, forklift truck, or with attachment ropes/straps (or similar appropriate attachment device(s)). In each case the package must be well balanced and positioned or fixed so that there is no possibility of sliding or other unintended movement of the package during the transport.

Figure 7.1. – Stacking of the slewing bearings

Figure 7.2. – Stacking spacers

7.3. HANDLING PACKED BEARINGS

If the bearings are packed, i.e. wrapped in anti-corrosive paper and foil, they must have been delivered on a pallet or in a box/ crate, hence they should be transported as described in section [Bearings on Pallets or in Boxes/Crates].

7.4. MANIPULATION OF UNPACKED BEARINGS

Unpacked bearings must be handled using 3 transportation eye bolts, bolted in the so called transportation holes or in special cases with the use of appropriate industrial grade slings. The lifting points in any case must be equally spaced around the circumference of the slewing bearing.

Furthermore, the application angle, the angle between the horizontal plane and the pulling direction of the individual chain/rope must be greater than 80°, to prevent radial and torque loads on the lifting bolts, which can in turn cause the deformation of the bearing rings.

Figure 7.3: Left correct angle of the lifting ropes/chains, right: incorrect angle of the lifting ropes/chains.

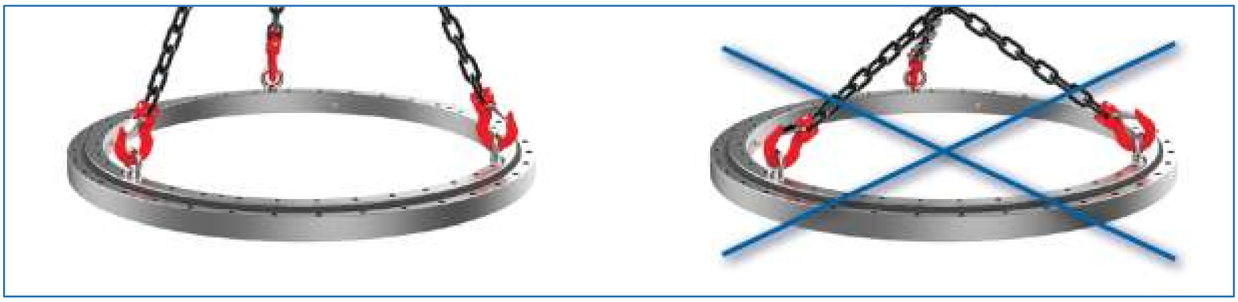


Figure 7.3. – Lifting the slewing bearing using eyebolts and transportation threads

REVISION HISTORY

Rev.	Date	Author(s)	Description
0	29.04.2022	L. Šparovec	Initial document
1	14.09.2024	M. Budja	Updated Table 6.6
2	12.05.2025	M. Budja	Updated Figure 6.1 & 6.2
3	17.09.2025	M. Budja	Updated Table 4.8, 4.9. & 4.10